

REMARKS

Reconsideration and allowance of this application, as amended, is respectfully requested.

This amendment is in response to the Office Action dated February 28, 2003. Appreciation is expressed to the Examiner for the allowance of claims 10 and 12 and the indication of allowable subject matter in claim 3.

By the present amendment, each of claims 1, 4, 10, 12 and 13 has been amended to adopt the suggestion made by the Examiner in paragraph 1 of the Office Action. Also by the present amendment, rejected independent claims 1, 4 and 13 have been amended to clarify the invention. In addition, new claims 15-32 have been added to further define the invention.

Briefly, the present invention is directed to resolving a problem that can exist in aluminum conductors formed adjacent to one another on a main surface of a substrate when copper is added to the aluminum to help prevent breakage of the aluminum conductors. Although copper is excellent for strengthening the aluminum to avoid the breakage of the conductors, it can create a problem by being adsorbed or precipitated from the conductor. The resulting precipitant can lead to short circuiting between the aluminum conductors formed adjacent one another on the main surface of the substrate.

Accordingly, the present invention is directed to adding nickel to the aluminum conductors in a sufficient amount to prevent the undesirable precipitation of the copper. In other words, the present invention is directed to resolve a specific problem which exists with aluminum conductors formed on a main face of the substrate, which aluminum conductors contain copper to help avoid breakage of the lines and further contain a sufficient amount of nickel to suppress diffusion of the

copper to prevent precipitation of the copper, thereby preventing short circuiting between the aluminum conductor lines.

An important aspect of the present invention is that it is specifically directed to a problem involving aluminum conductors including copper which are spaced close to one another on a main face of a substrate. More specifically, as defined in dependent claims such as 2 and 25-29, the aluminum conductors are spaced not more than 0.4 μm apart from one another. In other words, if the aluminum conductors were not formed closely adjacent to one another on a main face of a semiconductor substrate, the precipitation of the copper from the aluminum substrate would not be a problem since it would not lead to short circuiting with the closely adjacent aluminum conductor. As defined by newly submitted claims 21-23 and discussed on page 7, lines 13-22 of the specification, this problem is particularly significant in situations where the aluminum conductors are formed by an etching operation. Since, precipitates containing copper remain during the etching without being removed, short circuiting can occur because the conductor spacing is narrow.

Reconsideration and removal of the rejection of claims 1, 2, 4, 13 and 14 over the cited references to Joshi (USP 6323554) in view of Japanese Patent 363230845A to Kusano is respectfully requested.

In the Office Action, it is recognized that Joshi merely serves as a general teaching of showing conductors formed on a substrate, and does not teach or suggest aluminum conductors containing copper and nickel. Instead, the secondary reference to Kusano is cited as teaching a conductor containing aluminum as a main constituent and also containing copper and nickel. It is also recognized in the Office Action that Kusano fails to teach or suggest that the nickel is provided in an amount sufficient to suppress diffusion of copper atoms in the aluminum conductors.

In response to this rejection, each of the independent claims has been amended to specifically define that the aluminum conductors are formed:

"adjacent to one another on a portion of a main face of the substrate."

This has been done to emphasize the distinction over the Kusano reference in which the conductors in question are bonding wires. As such, the technology and the problems being dealt with in Kusano concerning bonding wires are completely different than the problem dealt with in the present invention in terms of preventing short circuiting between closely adjacent aluminum conductors on the face of a substrate. With regard to this, attention is directed to the case of *In re Fine*, 5 USPQ 1596 (Fed. Cir. 1988). As stated in that case:

"To imbue one of ordinary skill in the art with knowledge of the invention in suit, when no prior art reference or references of record convey or suggest that knowledge, is to fall victim to the insidious effect of a hindsight syndrome wherein that which only the inventor taught is used against its teacher...one cannot use hindsight reconstruction to pick and choose among isolate disclosures in the prior art to deprecate the claimed invention." 5 USPQ 2d 1600

With regard to the present situation, it is respectfully submitted that taking an isolated disclosure of material used for a bonding wire from the Kusano disclosure and modifying the teachings of Joshi to change the material of Joshi's conductors represent exactly such hindsight reconstruction since, absent the applicants' own teachings, there is nothing in either reference to suggest this. Why would one utilize materials used in a bonding wire in Kusano in the conductors on the face of a substrate in Joshi? This is particularly the case since Kusano does not at all suggest the use of nickel to prevent the precipitation of copper to prevent short circuiting. Similarly, Joshi fails to recognize the advantage of nickel for this purpose. Only applicants' own teachings at all suggest the significance of using copper and nickel in an aluminum conductor to prevent short circuiting between closely spaced

conductors on a substrate surface. Therefore, in accordance with the teachings of *In re Fine*, reconsideration and removal of the rejection of claims 1, 2, 4, 13 and 14 over the combination of Joshi and Kusano is respectfully requested.

In further regard to the above matter, it is noted that independent claim 13, which defines the invention in terms of means for suppressing the diffusion of copper atoms to prevent precipitation of the copper has been amended to even further define that the means for suppressing prevents precipitation of the copper "from one of said aluminum conductors to an adjacent of one of said aluminum conductors. As such, the significance of the difference between claim 13 and the cited prior art is even further emphasized. As noted above, the prior art completely lacks any recognition of resolving the problem of avoiding precipitation of the copper from one aluminum conductor to an adjacent aluminum conductor.

Similarly, new independent claim 15 corresponds to independent claim 1, but includes the limitation that the aluminum conductors contain copper and also contain:

"nickel in an amount sufficient to prevent precipitation of said copper between adjacent ones of said aluminum conductors."

Thus, claim 15, like amended claim 13, even further emphasizes the significance of the use of nickel in the present invention. As also noted in the case of *In re Fine*:

"Teachings of the references can be combined only if there is some suggestion or incentive to do so." 5 USPQ 2d @ 1599

Claims 13 and 15 particularly define the incentive in terms of preventing the precipitation between adjacent ones of the aluminum conductors. No such incentive is found in either of the cited references to Joshi or Kusano since they are completely lacking in any recognition of this problem or solution of the problem.

In addition to the above consideration of the independent claims, particular reconsideration of dependent claim 2 and newly added dependent claims 25-29 is respectfully requested. Claim 2 particularly emphasizes that the spacing between the conductors is not more than 0.4 μm at least at one area of the conductors. It is this extremely close spacing between the electrical conductors that lies at the heart of the problem of short circuiting between the conductor lines. In the Office Action, it is stated:

"regarding claim 2, neither Joshi et al nor Kusano et al teach a semiconductor device, wherein the spacing of the conductors is not more than 0.4 microns. It would have been a matter of obviousness for one having ordinary skill in the art to arrive at the optimal spacing of the conductors through routine experimentation."

the problem is not the new feature.
However, the defined spacing is not a matter of optimal spacing, it is a matter that this close spacing is what actually creates the problem which applicants have resolved. Further, neither Joshi nor Kusano suggest any such spacing, and, as such, are completely lacking in any teaching regarding meeting the claim limitations.

Regardless of whether one considers the spacing of the conductors to be a matter of "optimal spacing", as suggested in the Office Action, it is respectfully submitted that the statement made in the Office Action amounts to a statement that the invention is "obvious to try." Again referring to the *in Re Fine* decision, it is clearly stated:

"but whether or not a particular combination might be "obvious to try" is not a legitimate test of patentability." (5 USPQ 2d at 1599.)

This has long been the holding of the courts, noting the case of *in Re Antonie*, (195 USPQ 6 (CCPA 1977)). As noted in that case:

"the PTO and the minority appear that it would always be obvious for one of ordinary skill in the art to try varying every parameter of a system in order to optimize the effectiveness of the system even if there is no evidence in the record that the prior art recognized that the particular parameter affected the result. As we have said many times, obvious to try is not the standard of 35

USC §103... and over emphasis on the routine nature of the data gathering required to arrive at appellant's discovery, after its existence became expected, overlooks the last sentence of Section 103."

It is respectfully submitted that this statement of the court in the case of *in Re Antonie* clearly applies in the present instance. As discussed above, applicants invention, as defined in dependent claims 2 and 25-29 is particularly significant in closely spaced aluminum conductors containing copper when the spacing is less than 0.4 microns. Nothing in the cited prior art suggests or deals with this problem. The only way to arrive at this from the cited disclosures is either to utilize applicants own teachings or to use the "obvious to try" rationale specifically prohibited in both *in Re Fine* and *in Re Antonie*. Accordingly, particular consideration and allowance of dependent claims 2 and 25 through 29 is also respectfully requested.

Similarly, particular consideration and allowance of dependent claims 21-23 is respectfully requested. These new dependent claims particularly define that the interconnect pattern of the aluminum conductors is formed by being etched, and that the nickel and aluminum conductors is of a sufficient amount to prevent the precipitation of the copper to thereby prevent short circuiting between the conductors in the etched interconnect pattern. As noted above, this problem which occurs when interconnect patterns of aluminum are etched for providing closely spaced conductors creates a situation where short circuiting is especially likely to occur. The cited prior art is completely lacking in any recognition of this problem or suggestion of its solution. Therefore, particular consideration of these newly submitted claims 21-23 is respectfully requested.

Still further, particular consideration of new dependent claims 30-32 is respectfully requested. These claims combine the features of claim 2, discussed

above with the features of claims 21-23, also discussed above. As such, these claims define both a situation where the aluminum conductors are formed by etching and the specific spacing of 0.4 microns or less between the aluminum conductors. As such, these claims clearly define a structure having a problem which the present invention resolves which is quite distinct from the structure suggested by either of the cited references to Joshi or Kusano. Further, as noted above, nothing in either Joshi or Kusano would suggest the modifications proposed in the Office Action since these references failed to disclose either the structure of etching to form the aluminum conductors or the close spacing set forth between the aluminum conductors in claims 30-32. Therefore, particular consideration of these dependent claims is also respectfully requested.

If the Examiner believes that there are any other points which may be clarified or otherwise disposed of either by telephone discussion or by personal interview, the Examiner is invited to contact Applicants' undersigned attorney at the number indicated below.

Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The changes are shown on the attached pages, the first page of which is captioned **"VERSION WITH MARKINGS TO SHOW CHANGES MADE."**

To the extent necessary, Applicants petition for an extension of time under 37

CFR 1.136. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to the Deposit Account No. 01-2135 (Case No. 500.38949X00), and please credit any excess fees to such Deposit Account.

Respectfully submitted,
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Attachments

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS:

Please **amend** claims 1, 4, 10, 12, and 13 as follows:

1. (Twice Amended) A semiconductor device comprising a semiconductor substrate, and aluminum conductors formed in a plurality of layers on a side of a main face of the substrate which aluminum conductors comprise aluminum as a main constituent thereof, said aluminum conductors containing copper and nickel.

4. (Twice Amended) A semiconductor device comprising a semiconductor substrate, and a plurality of aluminum conductors formed adjacent to one another on a said portion of a main face of the substrate which aluminum conductors comprise aluminum as a main constituent thereof, a film adjacent to said aluminum conductors which adjacent film comprises titanium or titanium nitride as a main constituent thereof, said aluminum conductors containing copper and nickel.

10. (Twice Amended) A semiconductor device comprising a semiconductor substrate, and aluminum conductors formed on a side portion of a main face of the substrate which aluminum conductors comprise aluminum as a main constituent thereof, said aluminum conductors having at least one area in which conductor spacing is not more than 0.4 μm , a film adjacent to said aluminum conductors which adjacent film comprises one kind selected from the group consisting of ruthenium, platinum and iridium as main constituent thereof, said aluminum conductors

containing copper, wherein said aluminum conductors contain nickel not less than 0.02 at.% but not more than 1 at.%.

12. (Amended) A semiconductor device comprising a semiconductor substrate, and aluminum conductors formed on a sideportion of a main face of the substrate which aluminum conductors comprise aluminum as a main constituent thereof, said aluminum conductors containing copper and nickel, wherein each of the aluminum conductors has at least one area in which conductor spacing is not more than 0.4 μm and wherein the content of nickel contained in said aluminum conductors is not less than 0.2 at.% but not more than 1 at.%

13. (Amended) A semiconductor device comprising:
a semiconductor substrate,
a plurality of aluminum conductors formed in a plurality of layers adjacent to one another on a sideportion of a main face of the substrate which aluminum conductors comprise aluminum as a main constituent thereof, said aluminum conductors containing copper; and

means for suppressing diffusion of copper atoms in said aluminum conductors to prevent precipitation of the copper from one of said aluminum conductors to an adjacent one of said aluminum conductors.